National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

EX PARTE OR LATE FILED

NASA

Reply to Attn of O

JUL 6 1995

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M. Street, NW
Washington, DC 20554

RECEIVED

JUL 7 1995

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Re: Ex Parte Presentation
CC Docket No. 92-297

Dear Mr. Caton:

Enclosed is a report by the National Aeronautics and Space Administration detailing additional analysis of the Bellcore report, "Interference Analyses for Co-Frequency Sharing of the 28 GHz Band by the Local Multipoint Distribution Service (LMDS) and the Fixed Satellite Service (FSS)." This report augments the initial assessment of the Bellcore findings filed with the FCC on June 9, 1995.

We respectfully request that the enclosed information be associated with the above referenced proceeding because it addresses issues relevant to the proceeding.

Sincerely,

for Charles T. Force
Associate Administration for
Space Communications

Enclosure

cc:
FCC/Chairman Reed E. Hundt
FCC/Commissioner James C. Quello
FCC/Commissioner Susan P. Ness
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Additional NASA Comments on the Bellcore Study

Introduction

The Bellcore study entitled "Interference Analyses for Co-Frequency Sharing of the 28 GHz Band by the Local Multipoint Distribution Service (LMDS) and the Fixed Satellite Service (FSS)" purports to show that LMDS and FSS co-frequency sharing is feasible in the 28 GHz band. This is opposite to the conclusion drawn by the NRMC in its report to the FCC.

In the NASA Ex Parte Presentation, dated June 9, 1995, we discussed seven points of concern with this study. These were:

1. The spatial averaging, recommended by Bellcore, obscures the fact that LMDS services will frequently, if not continuously, be degraded in some areas.

2. The Bellcore study essentially ignored a serious degradation of subscriber-to-hub links by FSS terminals.

3. Re-specification of the LMDS parameters to partially mitigate FSS interference, as described in the Bellcore study, can aggravate the LMDS interference into FSS uplinks.

4. Acceptability of interference thresholds of as low as 8 dB, as suggested by the Bellcore study, is not consistent with data filed with the NRMC report.

5. The Spectrum Protocol would offer unusable spectrum to FSS service and degrade FSS service.

6. Clustering of service areas is more likely than suggested by Bellcore, and it has a more significant degradation when considering the narrow band FSS interferers.

7. The Bellcore analysis addressed point solutions for specific currently filed systems (Teledesic and Spaceway) but did not consider future FSS deployment of multiple systems (particularly multiple GEO FSS systems at 2° spacing).

In this presentation we wish to address points 5, 6, and 7 in greater detail. Specifically,

- The unavailability of the 2 MHZ guard bands (to avoid FSS interference into the LMDS hubs) in the Suite 12 type LMDS implementation would result in 10% reduction of FSS capacity.

- Preliminary NASA assessments of the impact of the Spectrum Protocol on FSS availability were too pessimistic. However, for this to be successful a very complex database must be maintained.

- Additional Simulation Results for FSS Interference into CellularVision LMDS Subscribers

    - Realistic clustering of LMDS cells and FSS terminals leads to significantly lower availabilities for LMDS subscriber units than were suggested in the Bellcore study.

    - Allowing for additional future FSS systems at 2 degree spacing leads to LMDS subscriber unit availabilities near 90%.

Given these later results and those provided to the FCC in our June 9, 1995 filing, it is the judgement of NASA that it is unwarranted to claim co-frequency sharing is possible for the FSS and LMDS services.

1. **The unavailability of the 2 MHZ guardbands (to avoid FSS interference into the LMDS hubs) in the Suite 12 type LMDS implementation would result in 10% reduction of FSS capacity.**

The Teledesic system makes use of a total of 400 MHZ of spectrum. Within this a Suite 12 type LMDS system could fit twenty 20 MHZ TV channels. The actual TV service bandwidth is 18 MHZ and the remainder serves as guard band. Eventually, this guard band will also serve as a return link from the subscriber units to enable interactive services. It is this feature which would suffer unacceptable interference from the FSS service if terminals were allowed to transmit in these bands. With twenty of these channels denied to the FSS service, a total reduction of 40 MHZ or 10% of the FSS spectrum results. Therefore, regardless of how well the dynamic segmentation process might perform (see section 2), the FSS will experience a reduction in capacity to 90% of that available if there were no co-sharing.

2. **Preliminary NASA assessments of the impact of the Spectrum Protocol on FSS availability were too pessimistic.**

The Bellcore recommended Spectrum Protocol can be illustrated with the aid of Figure 1. We examine the instance of the Teledesic FSS system co-sharing spectrum with a Suite 12 type LMDS system. A Teledesic supercell consists of nine cells which share the same 400 MHZ spectrum on a time-shared basis. At a specific time slot, say T_6, a maximum of 1440 16 Kbps

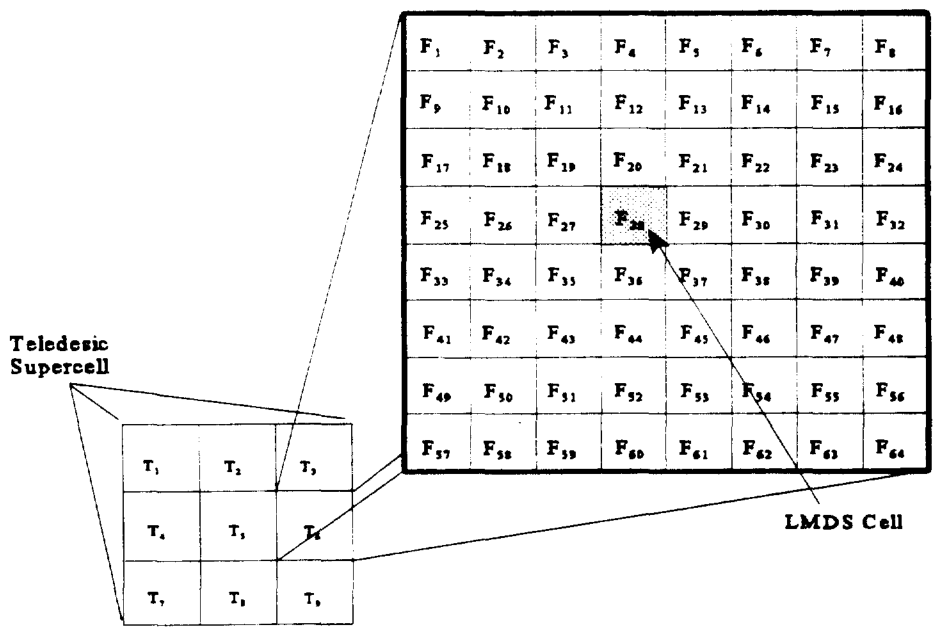

Figure 1- Cell by Cell Segmentation to Mitigate FSS/LMDS Interference

TST terminals can simultaneously be active within this bandwidth. Ordinarily with co-sharing of spectrum the uplink transmissions from these terminals would interfere with the LMDS subscriber units within this Teledesic cell. The LMDS cells are much smaller than a Teledesic cell. The inset illustrates how one might overlay 64 smaller LMDS cells onto the larger Teledesic cell. If we assume the 1440 terminals are evenly distributed among these 64 LMDS cells, within each LMDS cell there would be 22-23 TST terminals. By the Spectrum Protocol, the 400 MHZ spectrum would be segmented on a cell by cell basis so that these terminals would have a small primary allocation F_1 thru F_{64}. The LMDS service would be primary in the remaining spectrum of each cell, which differs cell to cell. By this the two services are isolated in frequency and the interference mitigated. 1440 Terminals within 400 MHZ would suggest each terminal transmits on a 278 KHz carrier, and 6.1-6.4 MHZ of bandwidth would be needed per LMDS cell to accommodate the 22-23 terminals. This amount could be set aside within each LMDS cell without significantly impacting the spectrum available for LMDS service (394 MHZ would remain). The set-aside would be a different portion of the spectrum for each LMDS cell so that the terminals would not interfere with each other, but the aggregate FSS spectrum would be the 400 MHZ needed by Teledesic for the FSS service.

If these assignments were static, such an arrangement would result in significant degradation of channel availability for the FSS service. Using the Teledesic example, 400 MHZ of spectrum would offer 1440 simultaneous 278 KHz channels for the 16 Kbps TST service. If all are independently available, the Erlang B formula would indicate these channels could be utilized with 94% efficiency (1359 erlangs / 1440 channels) and perceive a channel availability of 99.9%. With a static division of this traffic among 64 LMDS cells, the 22-23 channels available would have to service a traffic of about 20.8 erlangs. The Erlang B formula[a], in this case, would indicate the terminals would perceive a channel availability of only about 87.6%. To avoid such degradation, it would be necessary to allow the segmentation to be a dynamic process to allow for surges in traffic demand in certain cells. That is, the set-aside bandwidth F_{28} in LMDS cell 28, for example, would vary depending on the traffic demands. In the event that FSS bandwidth expanded beyond the set-aside, interference to the subscriber units in cell 28 would begin to occur. The Bellcore study claims this would be acceptable as this expansion would occur for only a small fraction of the time. Of course this process requires coordination throughout the larger Teledesic cell to avoid conflicts in spectrum assignments. The coordination could be done within the FSS

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[a] The Erlang B formula gives the probability of a blocked call as a function of the traffic intensity E in Erlangs and the available number of channels N. One form of this equation is:

$$p(blocked.call)\ \frac{\left[\frac{\left(\frac{E}{N}\right)^N}{N!}\right]}{\sum \frac{E^N}{i!}}$$

where the summation if over (0,N). For a large number of channels and where p < .05, this formula can be approximated by:

$$p(blocked.call) \doteq \frac{\left[\frac{E}{N}\epsilon^{\left(1-\frac{E}{N}\right)}\right]^N}{\sqrt{2\pi N}}$$

satellite or within the terminals themselves. Two databases would need be maintained. One would track current channel assignments in the FSS band. Another would keep track of the LMDS set-asides. Both databases would have variations from cell to cell, from supercell to supercell, and perhaps nationally.

This process of spectrum expansion can be illustrated as shown in Figure 2.

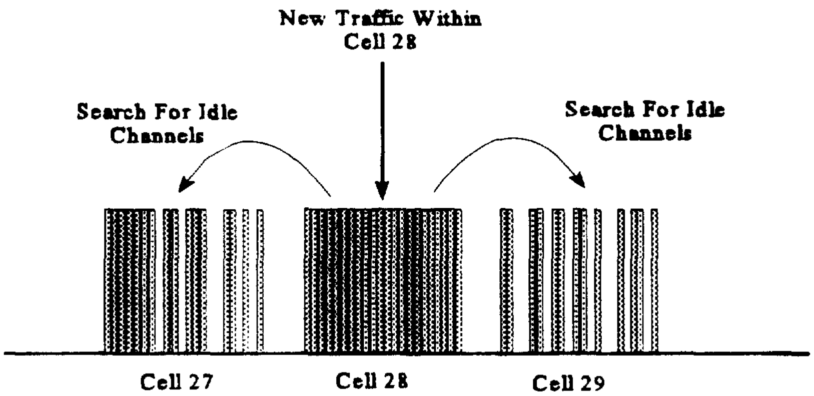

Figure 2 - Idle Channel Search within Adjacent Cell Set-Asides

In this, the set-aside for LMDS cell 28 is illustrated as fully utilized. New demand for channels would then be directed to adjacent bands in cell 27 or cell 29. These would be non-interfering channels in those cells, but they would cause interference within cell 28 as the demanding terminals would be within cell 28, and the sought for spectrum would be outside the cell 28 set-aside.

With an equal allocation of terminals among the 64 LMDS cells, one would expect that all cells would have the same probability of unmet spectrum demands. Consequently, there should be as many spectrum requests coming in from adjacent bands as there would be going out of cell 28. These extraneous demands would add additional traffic load and seemingly cause further degradation. However, the process takes advantage of the independence of cell statistics whereby it is very unlikely that all bands would simultaneously be full. By this process the perceived availability would actually be improved over the static segmentation case.

A simulation of this process was performed to evaluate the channel availability as perceived by the FSS. It would seem desirable to the LMDS providers that the terminals not seek spectrum over the entire allocation as this would necessarily mean interference within the cell could occur over the entire LMDS spectrum. Also, in the spirit of simplifying the Spectrum Protocol this would require less information on channel assignments and LMDS set-asides. That is, FSS terminals within a LMDS cell need to know only what is happening in adjacent LMDS cells rather than all 64 LMDS cells. Both goals can be accomplished by restricting the search to adjacent spectrum only so that interference is always restricted to the same bands. We then make use of the simulation and adjustment of the width of the search to evaluate the improvement in availability as the search width is increased. We specifically evaluate two cases: (1) the search in each adjacent band is restricted to ½ the set-aside bandwidth; (2) the search is allowed for the entire adjacent set-aside bandwidth.

The process is as follows:

1. A request for spectrum is made at random intervals such that the average request rate is E Erlangs per LMDS cell.

2. Spectrum is first sought for within the resident cell and assigned to the set-aside if available.

3. If resident set-aside is fully active, a search is then made in each adjacent cell.

4. If no spectrum is found in the adjacent cells the call is logged as being blocked.

5. Following a simulation of suitable length, the call blocking statistics are then computed.

To verify proper operation of the simulation, the static segmentation case is first analyzed (adjacent band search is not allowed). In this instance the Erlang B formula is applicable and the simulation results can be compared with theoretical.

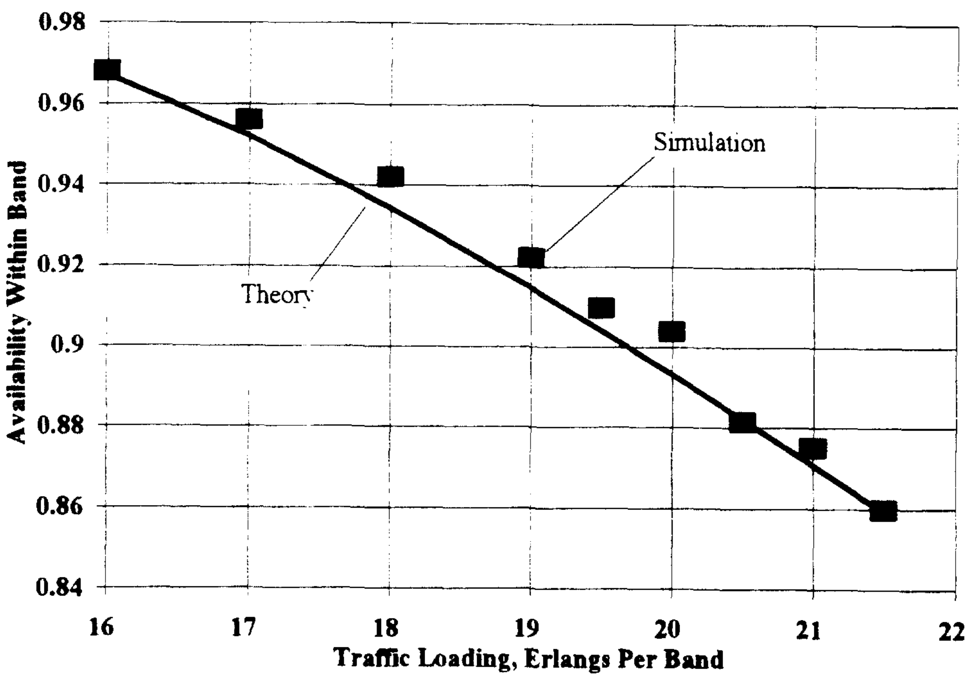

Figure 3 - Comparison of Simulation and Theoretical Results For Fixed Segmentation

For this particular LMDS cell, we assume 22 channels are available for use by the FSS terminals.

For the same 94% utilization of these 22 channels, the perceived availability can be seen to be 87.6%.

The fixed segmentation case provided the opportunity to determine a suitable simulation duration to get accurate statistics. For example, it was found that a significant interval was required before the first blocked call occurred. The initial starting condition was with no assigned channels. And the time taken for all channels to be assigned depended on the traffic intensity and the average time between call arrivals. We assumed an average call duration of 180 seconds. The average interval between calls depended on the traffic intensity. It was found necessary to allow for a timing offset of about 1500 seconds for the call blocking statistics to be stable. Perhaps the same could have been accomplished by an initial random assignment of channels equal to the average usage, but this was not attempted. For this particular LMDS cell, we assumed 22 channels were available for use by the FSS terminals. For the same aforementioned 94% utilization, the traffic loading in a LMDS cell would be 20.8 erlangs and the perceived availability of these channels can be seen to be about 87.6%.

The simulation then was adjusted to allow for spectrum search in each of the adjacent cell set-asides. The was done in the spirit of simplifying the Spectrum Protocol by requiring less information on channel assignments and LMDS set-asides. That is, FSS terminals within a LMDS cell need to know only what is happening in adjacent LMDS cells rather than all 64 LMDS cells. Equal traffic intensity was present in each of the 64 cells. The results are given in Figure 4.

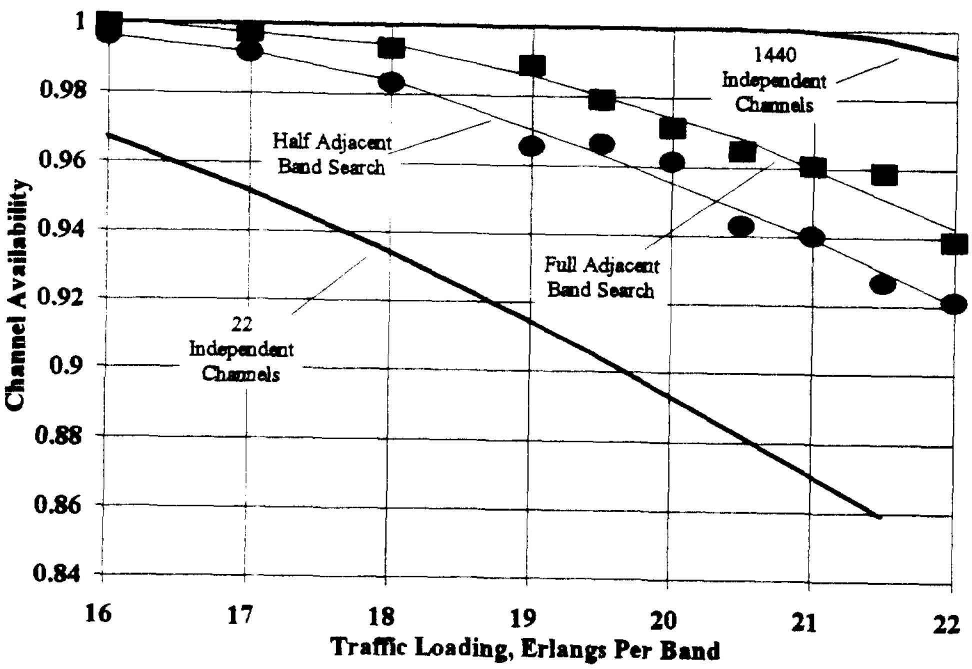

Figure 4- FSS Availability With Dynamic Segmentation (Variation on Bellcore Spectrum Protocol)

The lower curve repeats the results of the static segmentation case (terminals only have access to 22 channels). The topmost curve is the theoretical availability among the 1440 channels of an independent (primary allocated) Teledesic system. The connected symbols show simulation results for the cases where idle channels in adjacent cells are made available. The circular symbols are for the case where up to half the adjacent cell set-aside is available. Full availability of the adjacent cell se-aside is indicated by the rectangular symbols. Note that a significant improvement in availability is realized when only one-half the set-aside is made available. At a traffic intensity of 21.2 erlangs availability improves by more than six points over the static segmentation case to about 93%. Opening the adjacent set-aside to full bandwidth availability increase the FSS availability by another 3 points to about 95-96%. The trend seems obvious. To restore FSS availability to the independent case of 99.9% would require searches over the entire allocation. If the FSS provider were willing to operate at lower efficiency, say 77% (17 erlangs and 22 channels per cell on average), nearly 99.9% channel availability would be realized by searching only two adjacent cell set-asides.

We conclude from this that our original assessment of the impact of the Spectrum Protocol on FSS channel availability was too pessimistic. By simply allowing a terminal to access spectrum in two adjacent cells the degradation is reduced to about 3 points to 95-96%. And if its feasible to maintain the complex databases so that access is allowed to the entire allocation, there would be no degradation of the FSS availability. However, with all terminals having access to the entire allocation, uncontrolled interference will occur into the LMDS subscriber units as described below.

3. Additional Simulation Results for FSS Interference into CellularVision LMDS Subscribers

In its report, Bellcore presented LMDS availability results only for the case of Teledesic Standard Terminal (TST) uplink interference (at both T1 and 16 kbps rates) into CellularVision and Texas Instrument LMDS subscribers. For T1 rate TST interference, availabilities ranged from 95% (15 active TSTs clustered in 2-LMDS cells) to 99.85% (15 active TSTs randomly located over a 53 km x 53 km satellite cell roughly equal to 64 LMDS cells). For 16 kbps TST interference and 1440 simultaneously active terminals, Bellcore calculated an availability of 99.65% under non-clustered conditions.[b] Availabilities for other currently filed Ka-band FSS systems (i.e. Spaceway and Cyberstar) or multiple FSS systems were not analyzed. In its initial report, NASA presented simulation results for the case of TST 16 kbps narrow band uplink interference into LMDS. It was shown that the NASA availability result for no clustering (99.70%) agreed very closely with the Bellcore non-clustered result of 99.65%.[c]

Since then, NASA has performed additional analysis and simulation for other potential Ka-band

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[b]The availabilities cited here are for a 13 dB C/(N+I) threshold and assume clear sky conditions and the modified CellularVision LMDS link budget parameters listed in Table 1-1 of the Bellcore report.

[c]Recall, however, that the NASA result was based on treating the interference on a "best case" power basis while Bellcore claimed in its report that it treated interference on a "worst case" power density basis. It appears, however, that Bellcore did, in fact, also treat the narrow band interference on a power basis.

FSS interferers. Results show that:

- Good agreement is obtained between the Bellcore simulation results and the NASA simulation results for the case of Teledesic terminal interference into CellularVision subscribers.

- Availability is dependent on both FSS terminal density and - for a given FSS terminal type - the corresponding size of the protection zone around an LMDS subscriber. It is possible to have a high density of FSS terminals and still have relatively high LMDS availability if the protection zone around any single LMDS subscriber is small (e.g. 16 kbps TST terminal). Conversely, it is possible to have a low density of FSS terminals and yet have relatively low LMDS availability if the protection zone around an LMDS subscriber is large (e.g. T1 Spaceway terminal).

- In the case of narrow band FSS interference, availability is strongly affected by whether C/(N+I) is computed on a "best case" power basis or a "worst case" power density basis. Depending on the degree of terminal clustering, availabilities for the two approaches can differ as much as 85%.

- As would be expected, LMDS availabilities for Spaceway and Cyberstar are much higher (near 100%) than those for Teledesic under *non-clustered* conditions since the spot beam areas for these two systems are much larger than an LMDS cell (by a factor of 4590). Under realistic conditions, however, in which FSS terminals will likely be concentrated in the same high population density areas as LMDS within an FSS spot beam (as opposed to being uniformly randomly located over the entire spot beam area), LMDS availabilities for Spaceway and Cyberstar interferers are substantially worse than for Teledesic (e.g. 95.6% vs 99.85% for terminal concentrations in an area the size of a Teledesic spot beam).

- When larger numbers of FSS terminals associated with multiple GEO FSS systems under 2° satellite spacing are considered, LMDS availability can fall below 90%.

These results are described in more detail in the following paragraphs.

NASA computer simulation results to estimate LMDS availability for various interference scenarios are shown in Table 1. Note that the availabilities shown in parentheses for Teledesic are those calculated in the Bellcore analysis and are included for comparison[d]. Note also that the table lists the availability based on two different approaches for calculating interference. These are described in Section 4.3 of the NRMC Working Group 1 report. In the first approach, the interference power "I" is simply the total interference power falling within the receive channel bandwidth B. In the case of narrow band interference, "I" is found by simply summing the powers of the individual narrow band interferers who fall within the band. Hence, the C/(N+I) ratio is a true power ratio. In the second approach, the total power "I" calculated above is multiplied by the factor B/B_I (B_I is the interferer bandwidth). The power ratio $C/(N+I(B/B_I))$ is then equivalent to

[d]Availability is defined here to be the probability that the C/(N+I) power ratio (or Co/(No+Io) power density ratio) in the worst video channel for a randomly located LMDS subscriber meets or exceeds a given performance threshold (in this case 13 dB). Availabilities were calculated assuming clear sky conditions and the modified LMDS link budget parameters listed in the Bellcore report.

the power density ratio $C_o/(N_o+I_o)$ by dividing numerator and denominator by B. Note that since the factor B/B_I is greater than one for narrow band interferers, the power density approach is an upper bound on the interference while the in-band power approach is a lower bound on the interference. Availabilities based on $C_o/(N_o+I_o)$ therefore represent conservative or "worst case" estimates while those based on C/(N+I) represent optimistic "best case" estimates.

It can be seen from Table 1 that the NASA availabilities for the Teledesic T1 case agree very closely with the Bellcore results (Figure 3-4 in their report) even though the NASA simulations take into account FSS terminal interference from adjacent cells while the Bellcore analysis did not. The reason that adjacent cell interference is negligible in this case can be seen from Figure 5 which shows the protection zone around an LMDS subscriber which is being interfered with by a T1 Teledesic VSAT. Availability is directly related to both FSS terminal density and the size of the protection zone around the LMDS subscriber. The lower the density and the smaller the protection zone, the higher the availability. Looking at Figure 5, the only time the subscriber will suffer harmful interference is when one or more T1 VSATs falls into the narrow lobe protection zone. Since the protection zone does not extend beyond the cell border, interference from VSATs outside the cell is negligible. (It should also be noted that the protection zone size is also a function of the subscriber's distance from the hub. The size will decrease as the subscriber moves closer to the hub since the desired signal power will increase and he is able to tolerate more interference. The protection zone shown in Figure 5 is at its maximum size, since it is for a subscriber on the cell border. The relatively small protection zone and the small number of active terminals (15) leads to the relatively high availabilities shown in the table.

The availabilities for the narrow band Teledesic 16 kbps case are also relatively high despite the large number of active terminals (1440). Again, this can be related back to protection zone size. Figure 6 shows the protection zones around an LMDS subscriber which is being interfered with by a 16 kbps Teledesic terminal. Note that there are two zones shown since this represents a narrow band interference situation. The lobe indicated by the dotted line represents the "worst case" protection zone when interference is treated on a power density basis. The very small lobe within it represents the "best case" protection zone when interference is treated on a power basis alone. The difference in size between the two protection zones accounts for the large differences in availability.

Availabilities for Spaceway and Cyberstar are only listed for clustered situations since their availabilities under non-clustered conditions are near 100% when a uniform random distribution of FSS transmitters and LMDS receivers is assumed throughout the FSS beam area. This is due to the large size of the FSS spot beams compared to the LMDS cell area. Such an assumption, however, is not very realistic since the high traffic density for both FSS and LMDS services will likely occur in the same, more highly populated areas within the FSS spot beam. For example, when FSS terminal concentrations over an area equivalent to 10 SMAs (Statistical Metropolitan Areas) are considered, best case availabilities are 99.19% for Spaceway interference and 98.87% for Cyberstar terminal interference. For clustering over an area equivalent to a Teledesic satellite cell (i.e. 64 LMDS cells), it can be seen that LMDS availabilities are significantly worse for Spaceway and Cyberstar than Teledesic. This is true despite the fact that there are far fewer Spaceway terminals (240) or Cyberstar terminals (480) than, for example, Teledesic narrow band terminals (1440). The best availability for Cyberstar is only 95.58% while that for Teledesic (16 kbps) is 99.7% even though there are 3 times as many Teledesic interfering terminals. Again, this is due to the difference in protection zones for the two types of terminals. Figure 7 shows the protection zones around the LMDS subscriber when he is being interfered with by a 384 kbps Cyberstar terminal. The dotted line is the worst case protection zone (seen to extend beyond the cell boundary) while the solid line is the best case protection zone. Even this best case protection zone, however, is much larger than the one for Teledesic. Hence, even though there are far fewer terminals in the Cyberstar case, the probability that at least one will fall within an LMDS subscriber's protection zone is much larger. This leads to the lower availability.

Similarly, Figure 8 shows the protection zones for the case of Spaceway T1 interference. Note that the protection zone sizes are about the same as those for Cyberstar. The fact that there are only half as many terminals (240 vs 480), however, leads to somewhat higher availabilities.

The last entries in the table are for the case of FSS terminals uplinking to multiple FSS satellites spaced 2° apart in the geostationary arc. For example, high population density regions on the East coast of the U.S. are able to see geostationary satellites along an arc of 57°W - 110°W longitude with better than a 30° elevation angle. With a 2° spacing along this arc, 26 satellite positions are possible. The availabilities in the table assume that the FSS terminals communicating with these satellites have characteristics similar to those of the Spaceway system and are uniformly randomly located throughout a common 1° spot beam geographic area. Assuming that the spot beam bandwidth for each system is 120 MHZ (on each of two orthogonal polarizations) and that the uplink access for each system is FDMA, the uplink capacity per satellite per spot beam is approximately 120 T1 users (2 MHZ per T1 user). This leads to a total of 3120 simultaneously active T1 users for all 26 satellites. Under the best case assumption that these terminals are uniformly randomly located over the entire 1° spot beam area (about 332000 km^2), the LMDS availability is about 99.5%. If it is assumed that they are concentrated in an area equivalent to 10 SMAs (equivalent to 240 LMDS cells), then the availability drops to 89.25%.

The simulation results therefore are consistent with what one would expect when both FSS terminal density and protection zone size are considered. In cases where the protection zone does not extend beyond the LMDS cell border, the impact of adjacent cell interference is negligible. The results also indicate that even under best case conditions (i.e. use of the lower bound on interference), a moderate concentration of FSS terminals can yield unacceptable availability to LMDS.

Table 1 **Availabilities for Teledesic, Spaceway, and Cyberstar FSS Interference into CellularVision LMDS Subscribers**			
Terminal Type/No.	Clustering	Availability based on C/(N+I) power basis	Availability based on Co/(No+Io) power density
15 active Teledesic T1 TSTs[e]	None (over 53 km x 53 km satellite cell)	NA	99.85% (99.85%)
	8-LMDS cells	NA	98.71% (98.75%)
	4-LMDS cells	NA	97.43% (97.5%)
	2-LMDS cells	NA	95.10% (95.0%)
1440 active Teledesic 16 kbps VSATs	None (over 53km x 53km satellite cell)	99.70% (99.65%)[f]	85.28%
	16-LMDS cells	99.3%	54.97%
	8-LMDS cells	98.48%	32.74%
	4-LMDS cells	96.64%	17.15%
	2-LMDS cells	93.83%	8.19%

[e]The number of active terminals per satellite cell is arrived at as follows. During a Teledesic satellite spot beam dwell time over a satellite cell, the uplink can accommodate up to 1440 basic channel (i.e. 16 kbps) FDM users over a 400 MHz bandwidth. Since a T1 user data rate is 96 times the basis channel data rate, up to 15 (1440/96) simultaneously active T1 users are possible within a satellite cell. Although the information data rate of the users are 1.544 Mbps, Teledesic uses an FDMA/TDM uplink multiple access method which results in a T1 user burst bandwidth of 26.5 MHz. Hence, Teledesic T1 users act as wideband interferers to LMDS subscribers.

[f]Availability stated by Bellcore to have been calculated on a $C_o/(N_o+I_o)$ power density basis.

Table 1 - Continued Availabilities for Teledesic, Spaceway, and Cyberstar FSS Interference into CellularVision LMDS Subscribers			
Terminal Type/No.	Clustering	Availability based on C/(N+I) power basis	Availability based on Co/(No+Io) power density
	64-LMDS cells[g]	96.63%	55.43%
	24-LMDS cells[h]	92.17%	29.53%
	16-LMDS cells	88.20%	19.54%
	8-LMDS cells	77.79%	10.68%
	4-LMDS cells	59.10%	5.16%
	2-LMDS cells	35.85%	2.69%
480 active Cyberstar 384 kbps VSATs (77 cm terminals)[i]	240-LMDS cells	98.87%	64.47%
	64-LMDS cells	95.58%	23.70%
	24-LMDS cells	89.37%	10.04%
	16-LMDS cells	83.37%	6.57%
	8-LMDS cells	69.9%	3.32%
	4-LMDS cells	48.19%	1.66%
	2-LMDS cells	27.26%	0.66%
Multiple FSS Systems. 26 Spaceway-type systems with a total of 3120 (26 x 120) FSS terminals.[j]	None (terminals randomly located over a 1° spot beam area (332000 km^2)	99.55%	93.42%
	Terminals concentrated in an area equivalent to 10 SMAs or 240 LMDS cells (see footnote 5)	89.25%	16.15%

[g]This clustering corresponds to concentrating the terminals in an area equivalent to a Teledesic satellite spot beam (53 km x 53 km).

[h]This clustering corresponds to concentrating the terminals in an area equivalent to an average size SMA (1737 km^2 or 670 mi^2). Assuming a square area, the dimensions are 41.7 km x 41.7 km (25.9 mi x 25.9 mi).

[i]480 active Cyberstar (384 kbps) terminals within a spot beam is arrived at as follows. Cyberstar will provide 20 (120 MHz) spot beams covering CONUS, Alaska, and Hawaii. Each spot beam, however, is essentially 2 overlapping spot beams operating on orthogonal circular polarizations and over separate 120 MHz portions of the uplink frequency band. Hence, there is effectively 240 MHz of uplink bandwidth available over the same spot beam geographic area. Since there is 240 MHz available and each 384 kbps user requires 500 kHz of bandwidth, up to 480 simultaneously active Cyberstar terminals are possible within the same spot beam geographic area. (In the Cyberstar system, the spot beams vary in size and shape according to traffic density and rain statistics over different regions.)

[j]3120 active T1 (Spaceway-type) terminals within the same spot beam geographic area is arrived at as follows. The spot beam capacity for a single Spaceway-type satellite is 120 T1 terminals assuming the satellite has overlapping spot beams on orthogonal polarizations. High population density regions on the East coast of the U.S. are able to see geostationary satellites along the 57°W - 110°W arc with better than a 30° elevation angle. Assuming 2° spacing along this arc, 26 satellite positions are possible. FSS terminals communicating with these satellites are able to be located in the same geographic area and share the same spectrum by virtue of the 2° satellite separation and FSS terminal antenna discrimination. This yields a total of 26 x 120 = 3120 simultaneously active T1 terminals within the same 1° spot beam geographic area.

Figure 5

Protection Zones for a CellularVision Subscriber Receiver being Interfered with by a T1 Teledesic TST VSAT

(Modified CellularVision LMDS Parameters; C/(N+I) threshold = 13 dB)

<u>LMDS Parameters:</u>

Hub EIRP (dBW):	10.8
Channel BW (MHz):	18.0
Cell Radius (km):	4.83 (3 miles)
Sub. Recv Peak Ant. Gain (dBi):	31.0
Thermal Noise Power (dBW):	-125.4
Received Carrier Power(dBW):	-93.56
Max Allowed I in Channel BW:	-106.62
Required C/(N+I) (clear sky):	**13.0 dB**

Subscriber Location: Edge of Cell

<u>Teledesic T1 TST Parameters:</u>

Transmit Power (dBW):	0.85 dBW (1.2 W)
Xmit Ant. Gain (dBi):	36.0
Xmit Ant. Size :	27 cm
Signal BW (MHz):	26.5 MHz (TDMA burst)
Sidelobe Discrimination:	**-38.2 dB (ITU Pattern)**
Antenna Elevation Angle:	40°

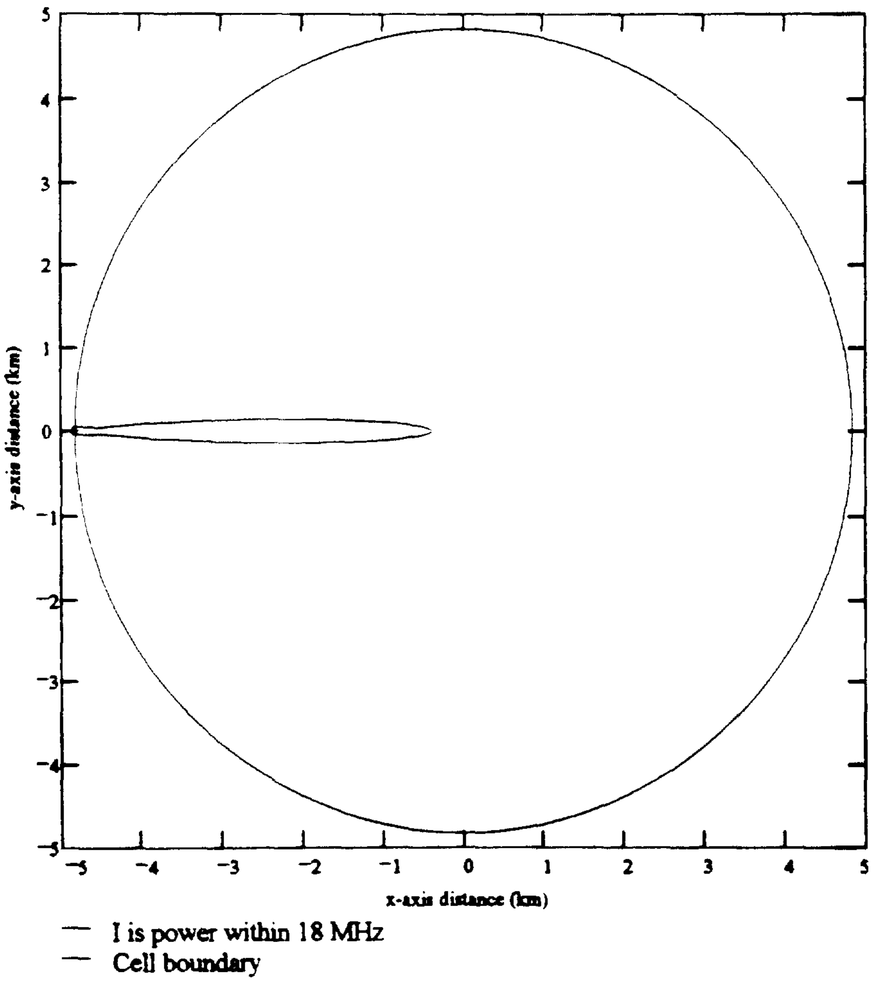

Figure 6

Protection Zones for a CellularVision Subscriber Receiver being Interfered with by a 16 kbps Teledesic TST VSAT

(Modified CellularVision LMDS Parameters; C/(N+I) threshold = 13 dB)

LMDS Parameters:

Hub EIRP (dBW):	10.8
Channel BW (MHz):	18.0
Cell Radius (km):	4.83 (3 miles)
Sub. Recv Peak Ant. Gain (dBi):	31.0
Thermal Noise Power (dBW):	-125.4
Received Carrier Power(dBW):	-93.56
Max Allowed I in Channel BW:	-106.62
Required C/(N+I) (clear sky):	**13.0 dB**
Subscriber Location:	**Edge of Cell**

Teledesic 16 kbps TST Parameters:

Transmit Power (dBW):	-19 dBW (12.6 mW)
Xmit Ant. Gain (dBi):	36.0
Xmit Ant. Size :	27 cm
Signal BW (MHz):	225 kHz (TDMA burst)
Sidelobe Discrimination:	**-38.2 dB (ITU Pattern)**
Antenna Elevation Angle:	40°

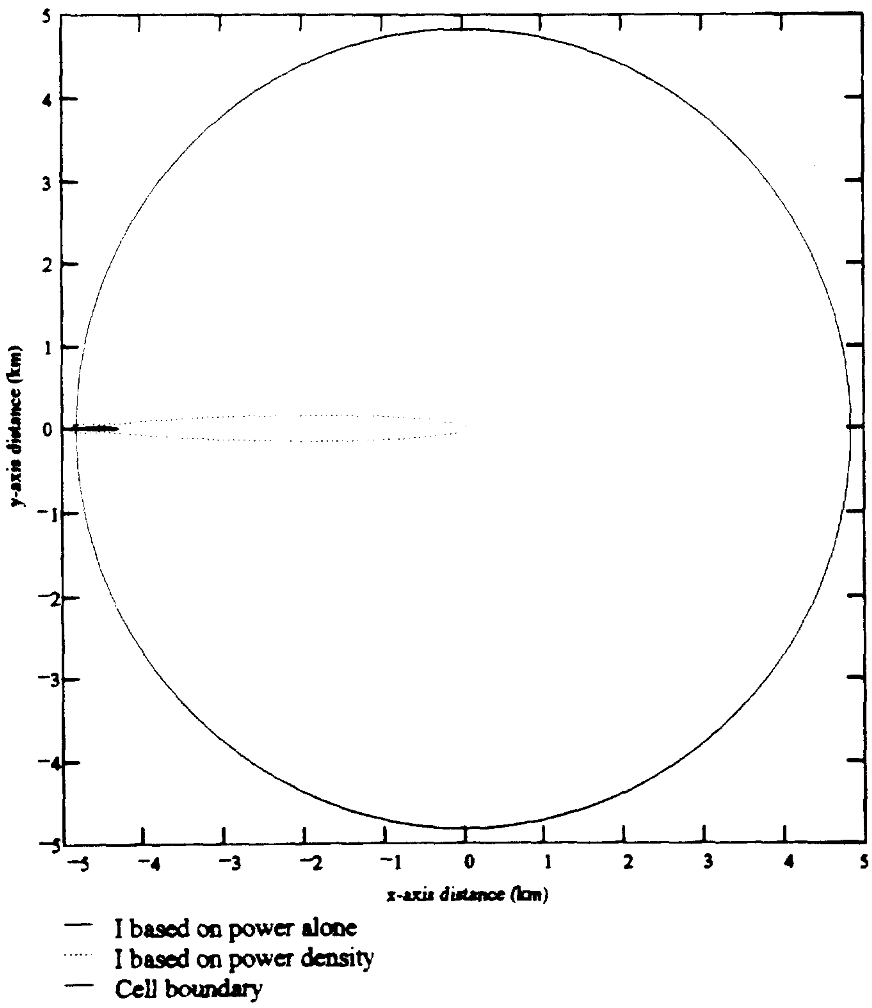

Figure 7

Protection Zones for a CellularVision Subscriber Receiver being Interfered with by a Cyberstar 70 cm 384 kbps VSAT

(Modified CellularVision LMDS Parameters; C/(N+I) threshold = 13 dB)

LMDS Parameters:

Hub EIRP (dBW):	10.8
Channel BW (MHz):	18.0
Cell Radius (km):	4.83 (3 miles)
Sub. Recv Peak Ant. Gain (dBi):	31.0
Thermal Noise Power (dBW):	-125.4
Received Carrier Power(dBW):	-93.56
Max Allowed I in Channel BW:	-106.62
Required C/(N+I) (clear sky):	**13.0 dB**

Subscriber Location: Edge of Cell

Cyberstar 70 cm 384 kbps VSAT Parameters:

Transmit Power (dBW):	0.0 dBW (1 W)
Xmit Ant. Gain (dBi):	44.5
Xmit Ant. Size :	70 cm
Signal BW (MHz):	500 kHz (FDMA U/L)
Sidelobe Discrimination:	**-47.7 dB (ITU Pattern)**
Antenna Elevation Angle:	30°

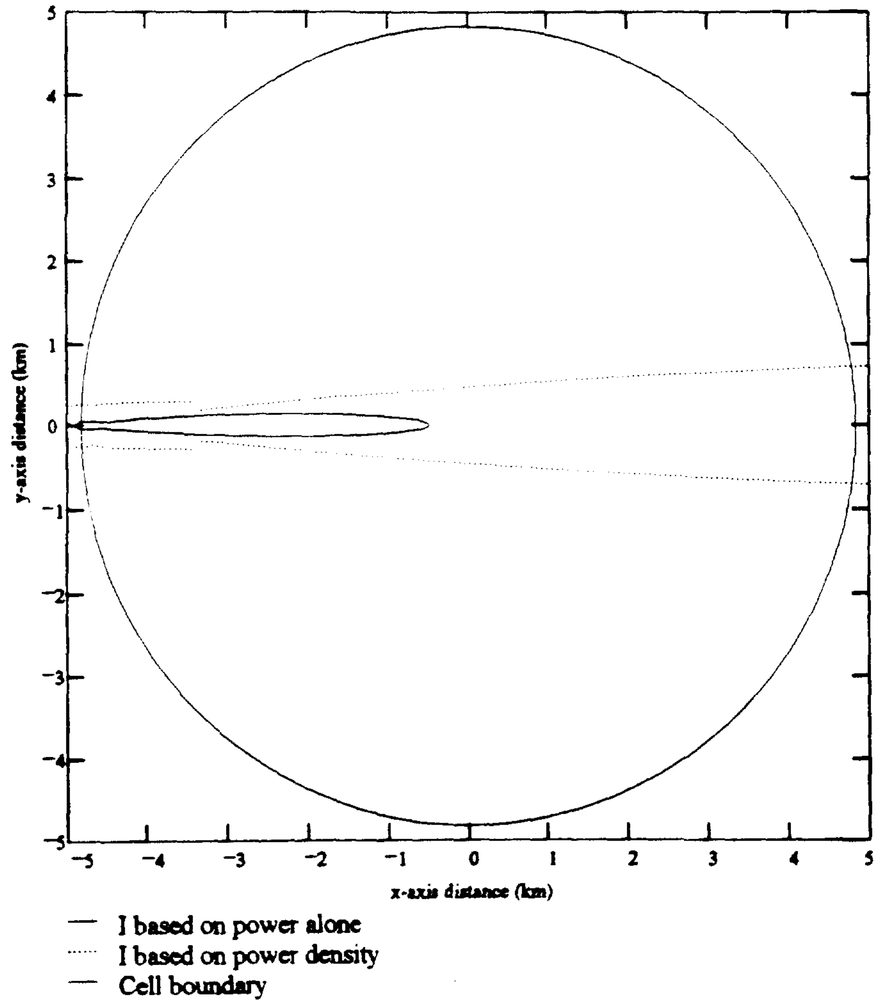

Figure 8

Protection Zones for a CellularVision Subscriber Receiver being Interfered with by a T1 Spaceway VSAT

(Modified CellularVision LMDS Parameters; C/(N+I) threshold = 13 dB)

LMDS Parameters:

Hub EIRP (dBW):	10.8
Channel BW (MHz):	18.0
Cell Radius (km):	4.83 (3 miles)
Sub. Recv Peak Ant. Gain (dBi):	31.0
Thermal Noise Power (dBW):	-125.4
Received Carrier Power(dBW):	-93.56
Max Allowed I in Channel BW:	-106.62
Required C/(N+I) (clear sky):	**13.0 dB**
Subscriber Location:	**Edge of Cell**

Spaceway T1 VSAT Parameters:

Transmit Power (dBW):	0.8 dBW (1.2 W)
Xmit Ant. Gain (dBi):	44.2
Xmit Ant. Size :	66 cm
Signal BW (MHz):	1.08 MHz (FDMA U/L)
Sidelobe Discrimination:	**-47.1 dB (ITU Pattern)**
Antenna Elevation Angle:	30°